

Contact interactions

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DIS 97

- Parameterization
- Effects at HERA
- Atomic Parity Violation
- Drell-Yan and LEP

papers by :	Altarelli et al.	hep-ph/970327
	Babu et al.	hep-ph/970329
	Barger et al.	hep-ph/970331
	Bartolomeo & Fabrichesi	hep-ph/970337
	Nelson	hep-ph/970337
	Buchmüller & Wyler	hep-ph/970

- broad excess at high χ^2 , x, y
- no clear resonance

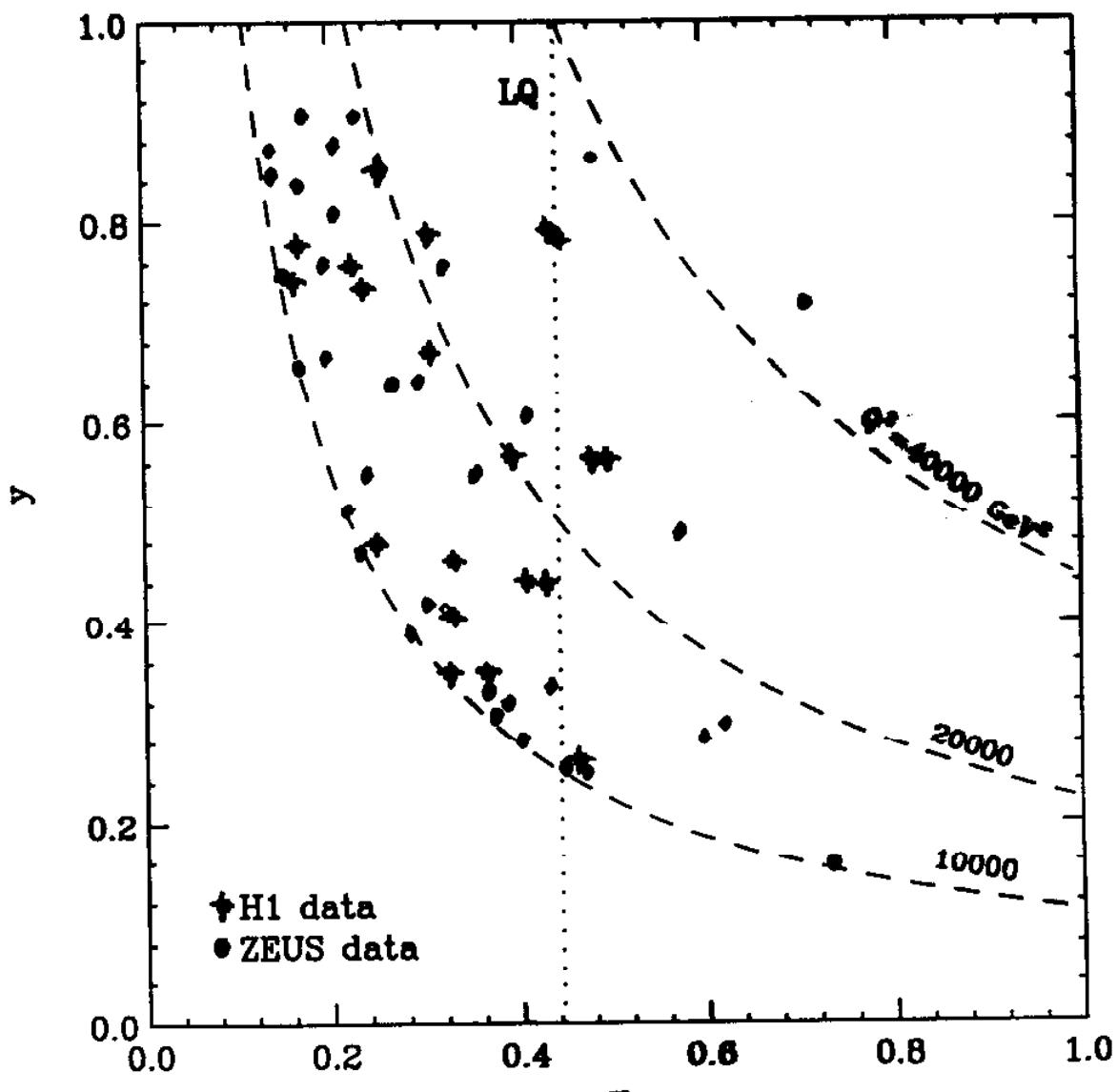


Fig. 1

Exchange of virtual, new particles?

Parameterization of contact terms

$$\begin{aligned} \mathcal{L}_{\text{eff}} = \sum_{q=u,d} & \left[\gamma_{LL}^{eq} \bar{e}_L \gamma^\mu e_L \bar{q}_L \gamma_\mu q_L \right. \\ & + \gamma_{LR}^{eq} \bar{e}_L \gamma^\mu e_L \bar{q}_R \gamma_\mu q_R \\ & + \gamma_{RL}^{eq} \bar{e}_R \gamma^\mu e_R \bar{q}_L \gamma_\mu q_L \\ & \left. + \gamma_{RR}^{eq} \bar{e}_R \gamma^\mu e_R \bar{q}_R \gamma_\mu q_R \right] \end{aligned}$$

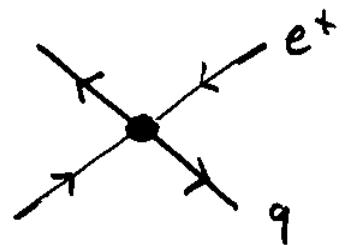
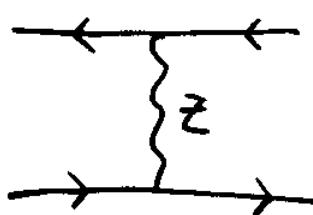
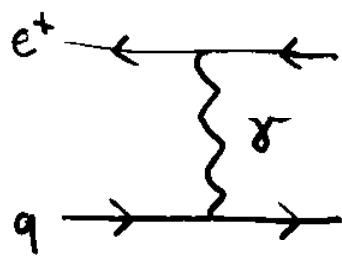
Connection to Eichten, Lane, Peskin

$$\gamma = \pm \frac{4\pi}{(\Lambda^\pm)^2} \sim \text{TeV}^{-2}$$

Connection to Z' -exchange

$$\gamma_{\alpha\beta}^{eq} = - \frac{g_\alpha^e g_\beta^q}{M_{Z'}^2} \quad \alpha, \beta = L, R$$

Contribantes via



$$M_{\alpha\beta}^{eq} = \frac{e^2 Q_e Q_q}{\hat{t}} + \frac{g_\alpha^{ze} g_\beta^{zq}}{\hat{t} - M_z^2} + \gamma_{\alpha\beta}^{eq}$$

$$\text{in } e^+ p \text{ and } e^- p : \hat{t} = -Q^2$$

$$\begin{aligned} \frac{d^2\sigma(e^+ p)}{dx dy} &= \frac{sx}{16\pi} u(x, Q^2) \left[|M_{LR}^{eu}|^2 + |M_{RL}^{eu}|^2 \right. \\ &\quad \left. + (1-y)^2 (|M_{LL}^{eu}|^2 + |M_{RR}^{eu}|^2) \right] + \dots \end{aligned}$$

$e^+ p$ Sensitive to γ_{LR}^{eu} , γ_{RL}^{eu}

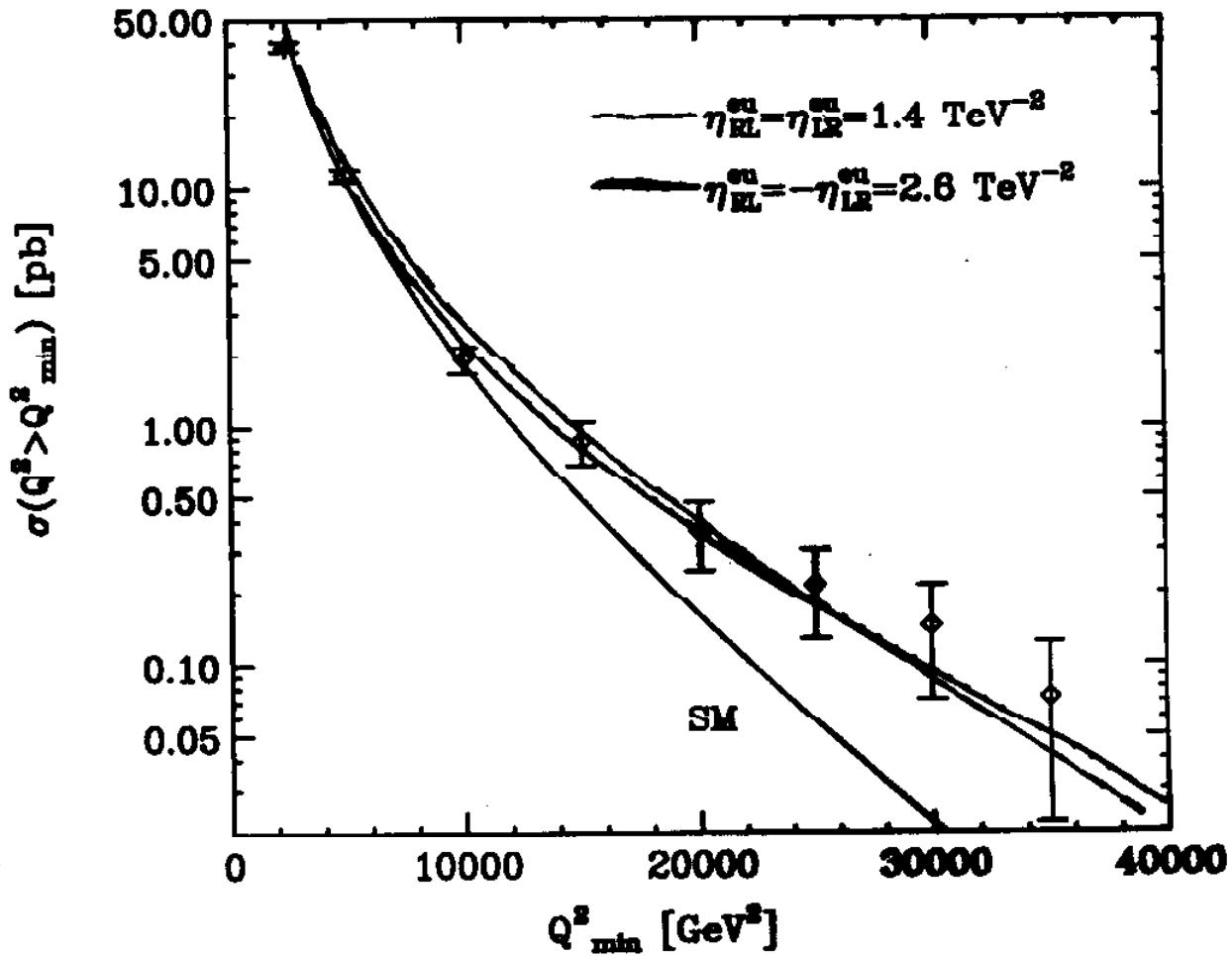
$$\begin{aligned} \frac{d^2\sigma(e^- p)}{dx dy} &= \frac{sx}{16\pi} u(x, Q^2) \left[(1-y^2) (|M_{LR}^{eu}|^2 + |M_{RL}^{eu}|^2) \right. \\ &\quad \left. + |M_{LL}^{eu}|^2 + |M_{RR}^{eu}|^2 \right] + \dots \end{aligned}$$

$e^- p$ Sensitive to γ_{LL}^{eu} , γ_{RR}^{eu}

Two examples:

$$\eta_{RL}^{eu} = \eta_{LR}^{eu} = 1.4 \text{ TeV}^{-2} \hat{\equiv} \Lambda \approx 3 \text{ TeV}$$

$$\eta_{RL}^{eu} = -\eta_{LR}^{eu} = 2.6 \text{ TeV}^{-2} \hat{\equiv} \Lambda \approx 2.2 \text{ TeV}$$



Shape is "better" for $\eta_{RL}^{eu} = -\eta_{LR}^{eu}$:

interference with γ -exchange
exactly cancels

Atomic parity violation ($^{133}_{55}\text{Cs}$)

$$Q_w = Q_w^{\text{SM}} - \frac{1}{\sqrt{2} G_F} [(N+2Z) \Delta \gamma^{\text{eu}} + (2N+Z) \Delta \gamma^{\text{eq}}$$

$$\Delta \gamma^{\text{eq}} = \gamma_{RR}^{\text{eq}} - \gamma_{LL}^{\text{eq}} + \gamma_{RL}^{\text{eq}} - \gamma_{LR}^{\text{eq}}$$

allowed by measurement

$$|Q_w - Q_w^{\text{SM}}| = 2.0 \pm 1.8$$

without cancellations ($|\Delta Q_w| < 1.8$)

$$|\gamma_{\alpha\beta}^{\text{eu}}| < 0.16 \text{ TeV}^{-2}$$

$$\Leftrightarrow \Lambda_{\text{eu}} \gtrsim 9 \text{ TeV}$$

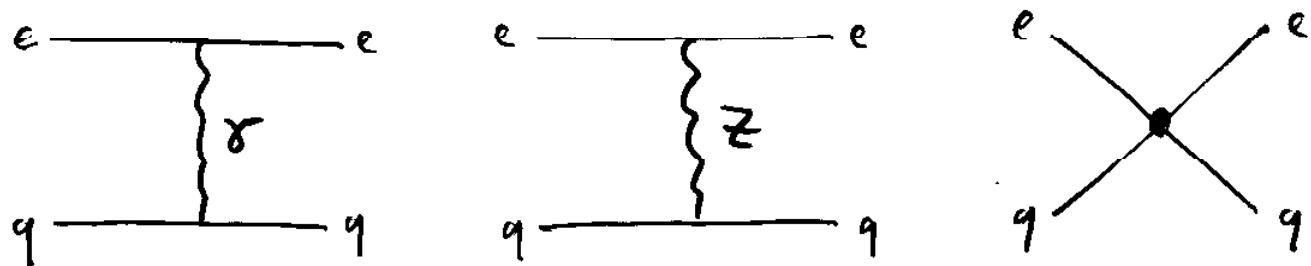
\Rightarrow Visible effect at HERA only if cancellations occur

$$\text{e.g. } \gamma_{RL}^{\text{eu}} = -\gamma_{LR}^{\text{eu}} = 2.6 \text{ TeV}^{-2}$$

$$+ : \gamma_{LL}^{\text{eu}} = -\gamma_{RR}^{\text{eu}} = 2.6 \text{ TeV}^{-2}$$

eeqq contact interactions affect

- Drell-Yan production
- $e^+e^- \rightarrow q\bar{q}$ at LEP



$$M_{\alpha\beta}^{eq} = \frac{e^2 Q_e Q_q}{\hat{s}} + \frac{g_\alpha^{ze} g_\beta^{zq}}{\hat{s} - m_z^2 + i m_{zz}} + \gamma_{\alpha\beta}^{eq}$$

Same reduced amplitude as at HERA

$$\text{but: } -Q^2 = \hat{t} \rightarrow \hat{s} > 0$$

constructive interference @ HERA

↔ destructive interference in s-channel

complementarity

Comparison of $M_{\alpha\beta}^{eq}$ ($\alpha, \beta = L, R$)

$eq \rightarrow eq$ at $\hat{t} = -20000 \text{ GeV}^2$

$q\bar{q} \rightarrow e^+e^-$ at $\hat{s} = (175 \text{ GeV})^2$

$eu \rightarrow eu$

$u\bar{u} \rightarrow e^+e^-$

LL $5.1 + \eta_{LL}^{eu}$

$-4.4 + \eta_{LL}^{eu}$

RR $3.9 + \eta_{RR}^{eu}$

$-3.0 + \eta_{RR}^{eu}$

LR $2.4 + \eta_{LR}^{eu}$

$-1.1 + \eta_{LR}^{eu}$

RL $1.7 + \eta_{RL}^{eu}$

$-0.2 + \eta_{RL}^{eu}$

$ed \rightarrow ed$

$d\bar{d} \rightarrow e^+e^-$

LL $-3.8 + \eta_{LL}^{ed}$

$3.9 + \eta_{LL}^{ed}$

RR $-2.0 + \eta_{RR}^{ed}$

$1.5 + \eta_{RR}^{ed}$

LR $-1.2 + \eta_{LR}^{ed}$

$0.6 + \eta_{LR}^{ed}$

RL $0.3 + \eta_{RL}^{ed}$

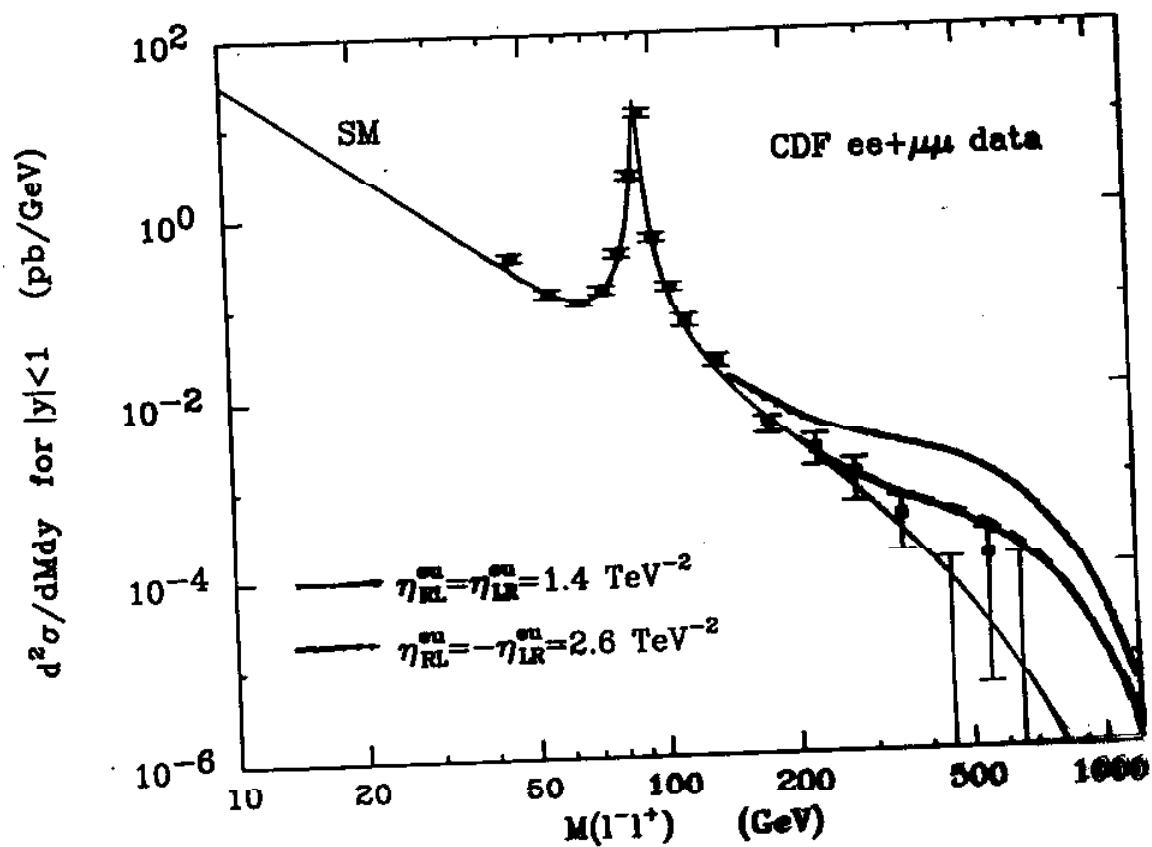
$-1.3 + \eta_{RL}^{ed}$

CDF: consider $\gamma_{LL}^{eu} = \gamma_{LL}^{ed} - \pm \frac{4\pi}{(\Lambda^{\pm})^2}$

$$\Lambda_{LL}^+ > 2.4 \text{ TeV}$$

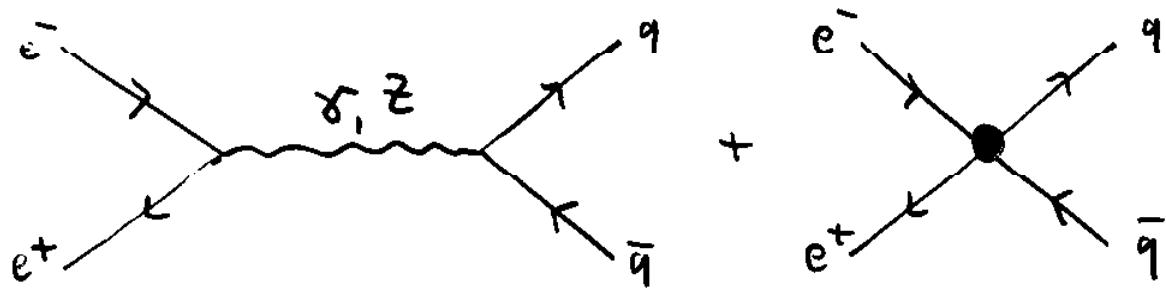
$$\Lambda_{LL}^- > 3.4 \text{ TeV}$$

at 95% CL



Must expand $\gamma_{RL} = -\gamma_{LR}$ for APY
 $\sigma(q\bar{q} \rightarrow e^+e^-) \sim \sum |\gamma|^2$ pnts stringen
 limit on additional terms at high

Constraints from LEP (DPAL)



limits on $\Lambda_{\alpha\beta}^{\pm}$, $\alpha, \beta = L, R$

$$\left. \begin{array}{l} \Lambda_{\alpha\beta}^{eu} > 1.1 \dots 2.4 \text{ TeV} \\ \Lambda_{\alpha\beta}^{ed} > 1.0 \dots 2.4 \text{ TeV} \end{array} \right\} 95\% \text{ C.I.}$$

- not as stringent yet as CDF
- can be improved soon

Conclusions

Contact interactions at scale $\Lambda \approx 3 \text{ TeV}$ give an acceptable description of HERA excess.

Atomic parity violation forbids sizable $A_e V_q$ chirality component

LEP2 and Drell-Yan at Tevatron probe same contact interactions. Sensitivity to particular chiral combinations is somewhat complementary to HERA.